OpenGL Techniques for Snow Leopard

Session 310

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OpenGL Techniques for Snow Leopard

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What Is OpenGL?

- API to interact with a GPU
- Provide a 3D cinematic experience
- Advanced user interface effects

Window Effects

Image Effects

Video Effects

OpenGL Programming Resources

- OpenGL Programming Guide (7th Edition)—"The Red Book"
- OpenGL Shading Language (3rd Edition)—"The Orange Book"
- Apple OpenGL ADC site:
  http://developer.apple.com/opengl/

OpenGL in Snow Leopard

Overview

- Dealing with multiple GPUs
- Writing well behaved fullscreen applications
- Multithreading and multiple contexts
- Sharing between OpenCL and OpenGL

OpenGL in Snow Leopard

New OpenGL extension support

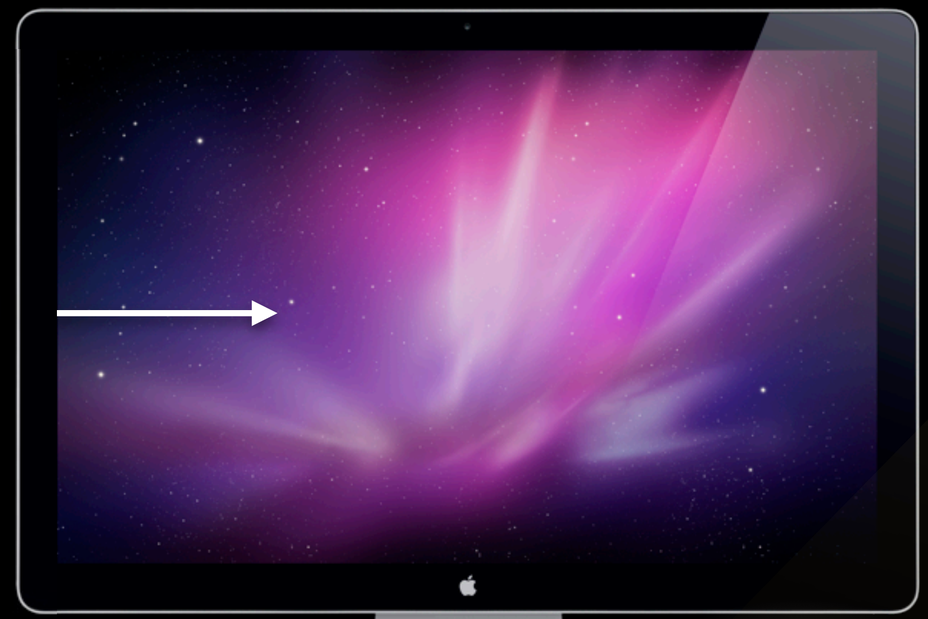
- APPLE_rgb_422
- ARB_color_buffer_float
- ARB_half_float_vertex
- ARB_texture_rg
- ARB_texture_compression_rgtc
- EXT_framebuffer_sRGB
- EXT_framebuffer_blit *(also available in Leopard)*
- EXT_framebuffer_multisample *(also available in Leopard)*

Managing Multiple GPUs

- Many Macs support multiple GPUs
  - Built-to-order MacPro with four GPUs
- Increasingly important
- Apps need to support dynamic environments, not just your MacBook!

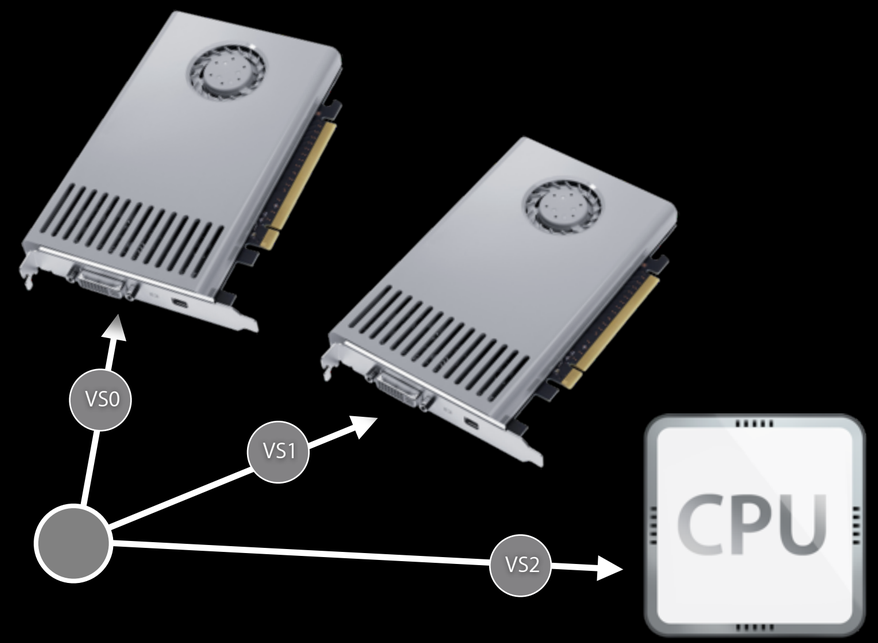
Multi-Monitor Multi-GPU Example

Seamlessly moving between GPUs



Virtual Screens

- Each hardware device is a virtual screen
- The software renderer is a virtual screen
- Unrelated to physical displays



- Virtual screen list is chosen by `CGLChoosePixelFormat`
- Context virtual screen is set by
  - `CGLUpdateContext` / `[ctx update]` (implicit update)
  - `CGLSetVirtualScreen` / `[ctx setCurrentVirtualScreen:]`
  - `CGLSetPBuffer`

Multiple Displays with Unique GPUs

Tracking when a view switches GPUs

- Maintain the correct virtual screen
  - Initialize virtual screen at startup
  - Check at all CoreGraphics display change notifications if a context has moved and ensure the capabilities are valid
- Surfaces unrelated to a display need to be manually managed

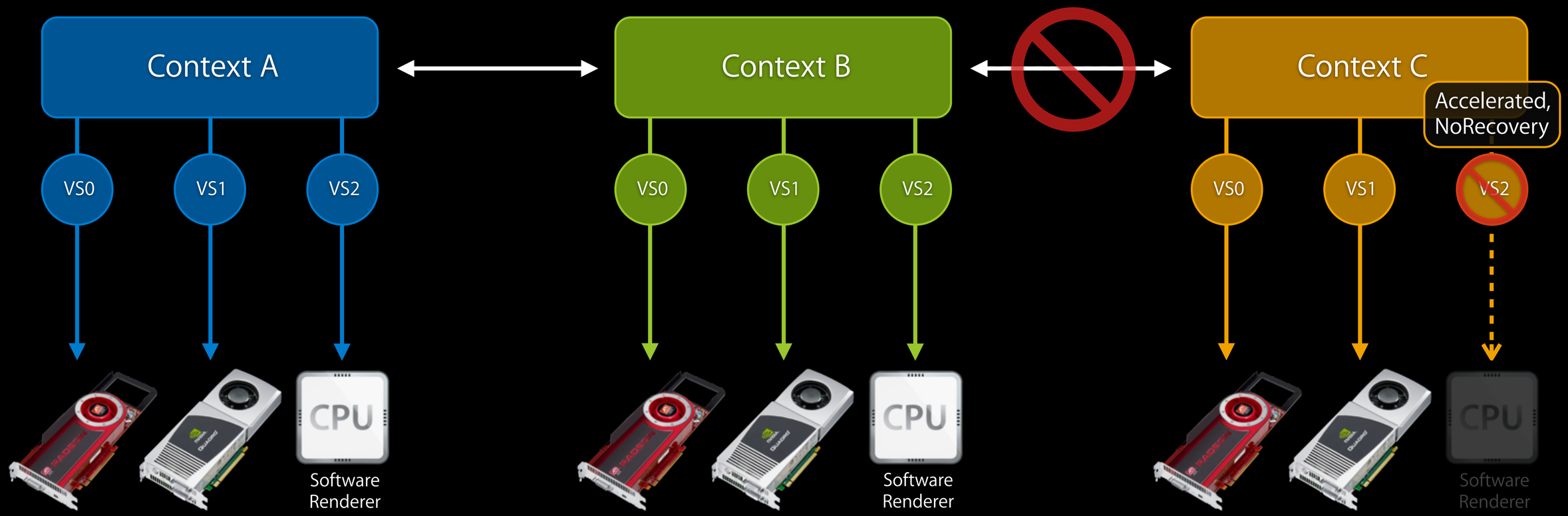
The Code…

```
- (void) update {
    [super update];
    newVirtualScreen = [self currentVirtualScreen];
    if(newVirtualScreen != oldVS) {
        // Check for GL support
        // Move any related contexts over
        oldVS = newVirtualScreen;
    }
}
```

- PBuffers and front/back buffers are not preserved on switch
- Not subclassing NSOpenGLView?
  - Register for CoreGraphics display change notifications

Sharing Contexts

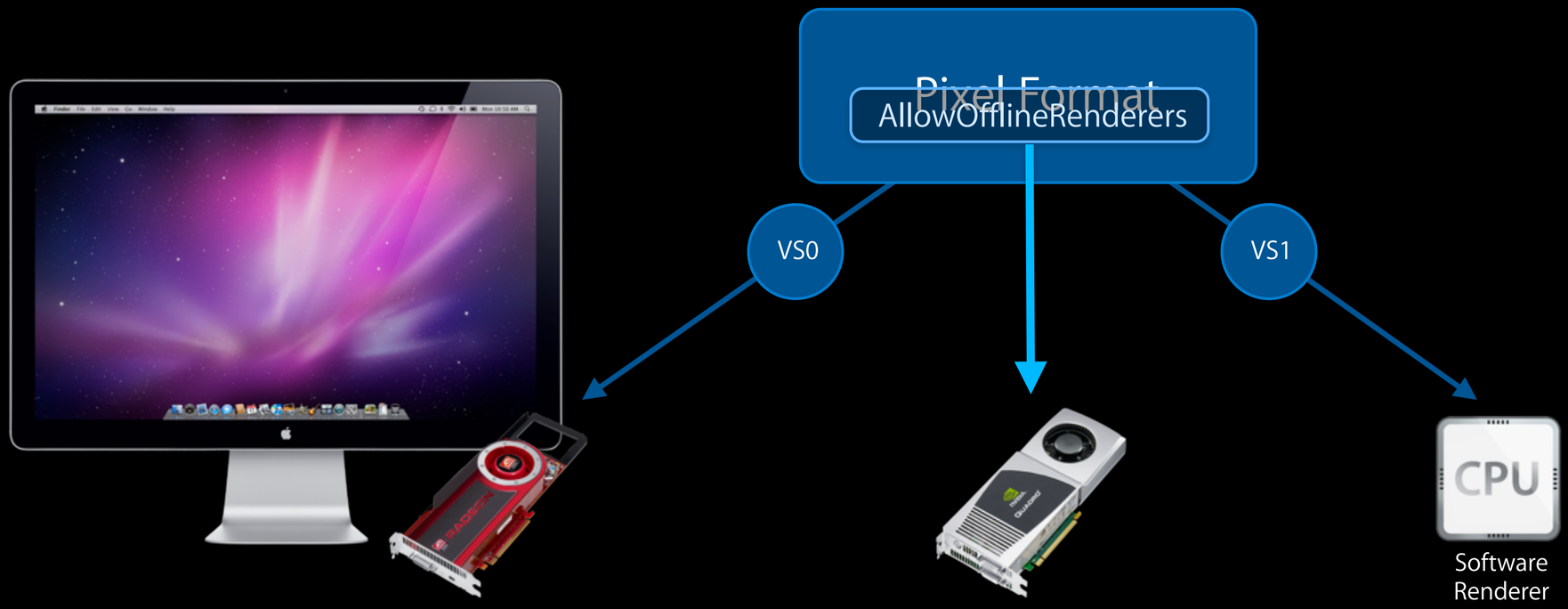
Maintain similar virtual screens



Offline Renderers

And surviving a hot-plug

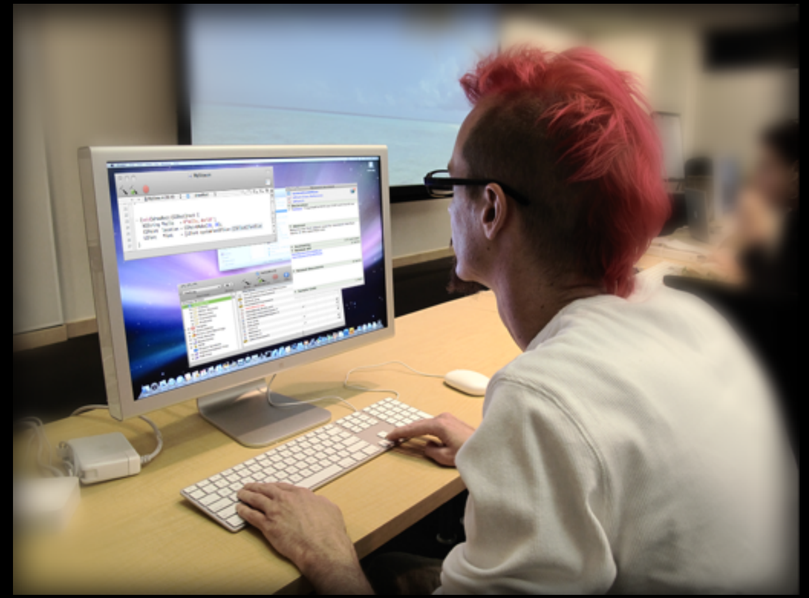
- You may have another GPU without a display on
- You may want another GPU to come online at a later date
- Add NSOpenGLPFAAllowOfflineRenderers to the pixel format attribute list



Our Recommendation

Test on a system with two GPUs and two displays

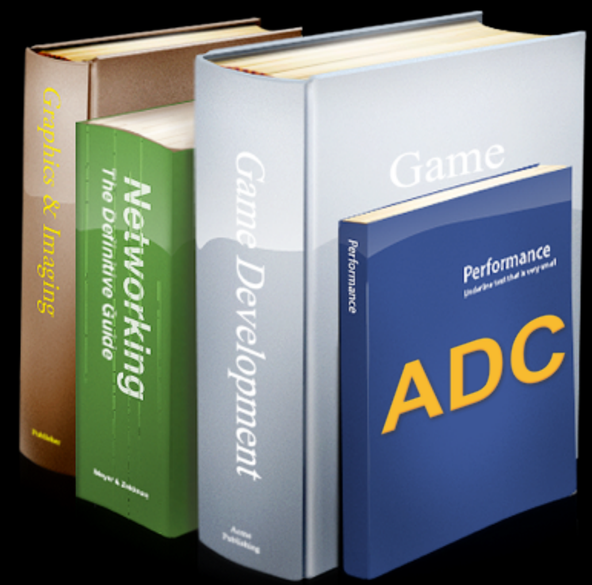
- Test that OpenGL rendering occurs on the same GPU that displays it
- Test hot-plugging a single display into multiple GPUs



More Multi-GPU Information

- ADC Tech Note (TN 2229)

  Supporting Multiple GPUs on Mac OS X



Full Screen Rendering

Why is it deprecated?

- Does not interact well with multiple GPUs
  - Can not always share contexts
  - Contexts must be created from scratch
- Covers up critical dialogs

There's a Better Way to Do It

It just works!

- Covering contexts automatically get benefits of "fullscreen"
  - Cache enhancements
  - Page flipping

Key Code Points

- Make a screen sized window

```
NSRect mainDisplayRect = [[NSScreen mainScreen] frame];
NSWindow win = [[NSWindow alloc] initWithContentRect:mainDisplayRect
                                                styleMask:...];
[win setContentView:myFullScreenNSOpenGLView];
```

- Set the window level above the Menu Bar

```
[myWindow setLevel:NSMainMenuWindowLevel+1];
```

FullScreenNSOpenGLView Example

Chris Niederauer
GPU Ninja

Deprecated API

- `kCGLPFAFullScreen`
- `CGLSetFullScreen()`
- Can’t depend on back buffer content!
  - `kCGLPFABackingStore` will prevent the performance gain

OpenGL and Multithreading

Avoiding land mines

- OpenGL is not per context thread-safe
- Convenience functions
  - CGLLockContext(ctx) / CGLUnlockContext(ctx)
  - CGLEnable(kCGLCEMPEngine)
- Or multithread everything else!

- ADC documentation

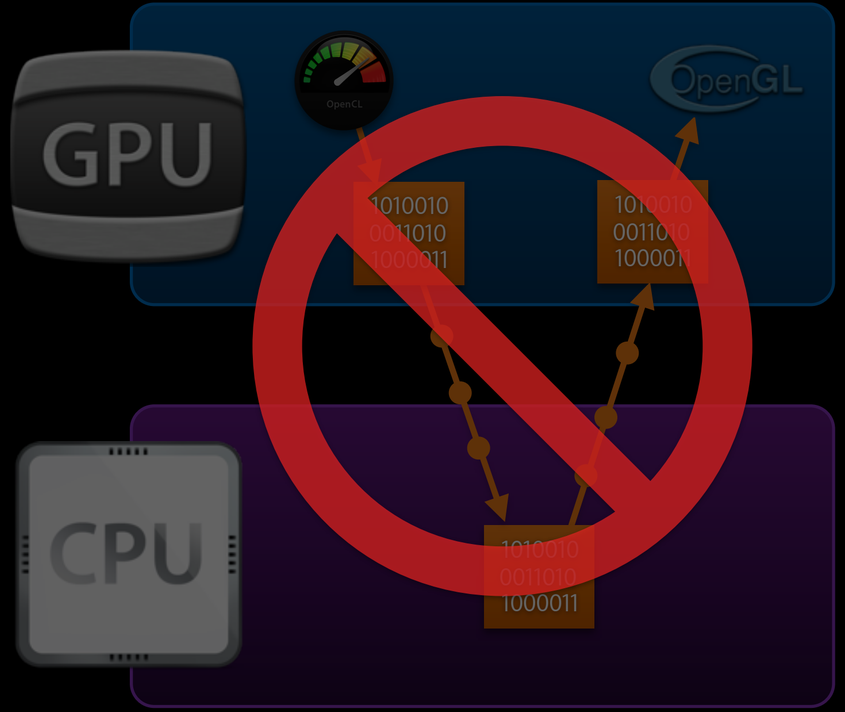
  OpenGL Programming Guide for Mac OS X: Multithreading and OpenGL

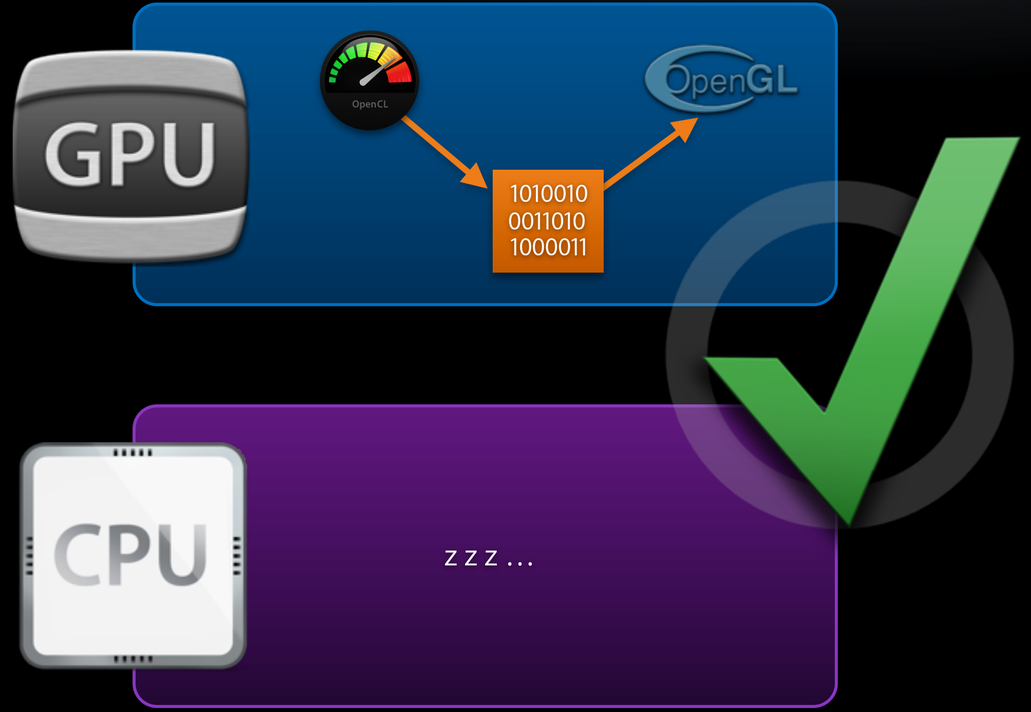
OpenCL

Working with OpenCL

The GPU goes to 11!

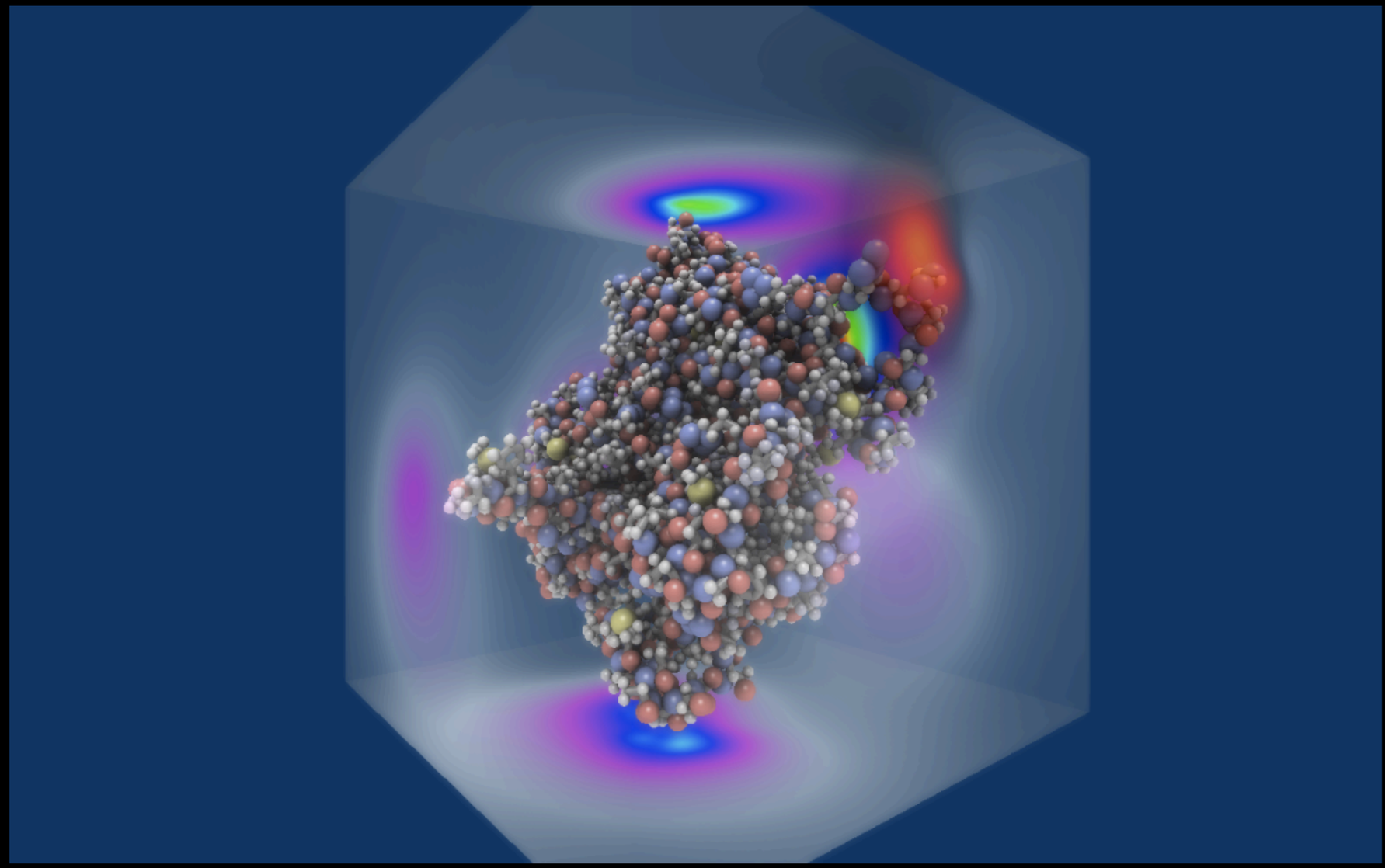
- OpenCL creates data on the GPU
- OpenGL consumes data on the GPU





OpenCL Sharing Texture Data

Molecule



Working with OpenCL

Basic OpenGL/OpenCL interactions

- Creating a CL context from a GL context
- Creating CL buffers from GL buffer objects
- Creating CL images from GL textures
- Sharing buffers and textures
- Supporting multi-GPU

Sharing Between OpenCL and OpenGL

Creating a CL context from a GL context

```
#include <OpenCL/cl_ext.h>
#include <OpenCL/cl_gl.h>
```

```
// Test for cl_APPLE_gl_sharing extension support and then find the
// clGetGLContextInfoAPPLE function pointer via clGetExtensionFunctionAddress
```

```
// Create a context that shares with an OpenGL context
CGLShareGroupObj share_group = CGLGetShareGroup(cgl_ctx);
cl_context_properties properties = { CL_CONTEXT_PROPERTY_USE_CGL_SHAREGROUP_APPLE,
                                     (cl_context_properties)share_group, 0 };
cl_context cl_ctx = clCreateContext(properties, 0, 0, 0, 0, &err);
```

```
// Compute OpenCL data on the same GPU as the OpenGL context
cl_device_id currentDevice;
err = clGetGLContextInfoAPPLE(cl_ctx, cgl_ctx,
          CL_CGL_DEVICE_FOR_CURRENT_VIRTUAL_SCREEN_APPLE,
          sizeof(cl_device_id), &currentDevice, NULL);
```

Sharing Between OpenCL and OpenGL

Creating CL buffers from GL buffer objects

```
glGenBuffers(1, &vboName);
glBindBuffer(vboName);
glBufferData( … );

cl_mem buffer = clCreateFromGLBuffer(cl_ctx, CL_MEM_READ_WRITE, vboName, &err);
```

Sharing Between OpenCL and OpenGL

Creating CL images from GL textures

```
glGenTextures(1, &texName);
glBindTexture(GL_TEXTURE_2D, texName);
glTexImage2D( … );

cl_mem buffer = clCreateFromGLTexture2D(cl_ctx, CL_MEM_READ_ONLY,
                                        GL_TEXTURE_2D, 0, texName, &err);
```

- Similar mechanism for other types:
  - `clCreateFromGLTexture3D( … )`
  - `clCreateFromGLRenderbuffer( … )`

Sharing Between OpenCL and OpenGL

Sharing buffers and textures

```
glFlush(); // use glFlushRenderAPPLE() on single buffered contexts

// Start sharing an OpenCL buffer
err = clEnqueueAcquireGLObjects(queue, 1, &buffer, 0, NULL, NULL);

// Do some CL operations like executing a kernel
// ...

err = clEnqueueReleaseGLObjects(queue, 1, &buffer, 0, NULL, NULL);
```

Sharing Between OpenCL and OpenGL

Supporting multiple GPUs

```
cl_device_id  deviceForVirtualScreen[32];
size_t        param_value_size_return;
clGetGLContextInfoAPPLE(cl_ctx, cgl_ctx,
    CL_CGL_DEVICES_FOR_SUPPORTED_VIRTUAL_SCREENS_APPLE,
    32 * sizeof(cl_device_id),
    &deviceForVirtualScreen[0], &param_value_size_return);

int numDevices = param_value_size_return / sizeof(cl_device_id);
```

```
- (void) update { // NSOpenGLView subclass method
    [super update];
    curVirtualScreen = CGLGetVirtualScreen(cgl_ctx);
    if (curVirtualScreen != previousVirtualScreen) {
        // Ensure supported OpenGL context movement
        curDeviceID = deviceForVirtualScreen[curVirtualScreen];
    }
}
```

The Tools

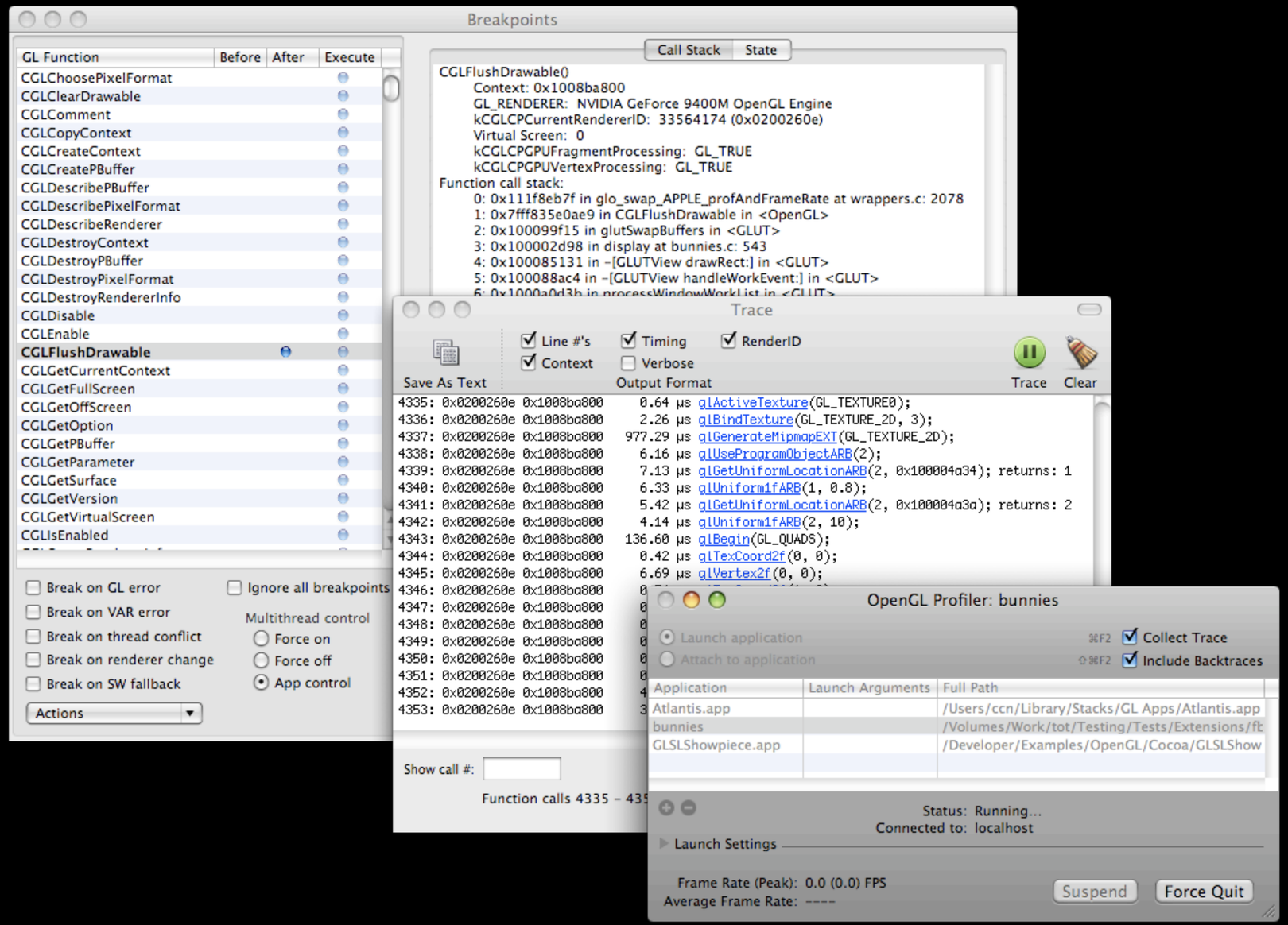
Critical to analyze performance

- OpenGL Profiler
- OpenGL Driver Monitor
- OpenGL Shader Builder
- Shark and Instruments

OpenGL Profiler

Performance and correctness debugger

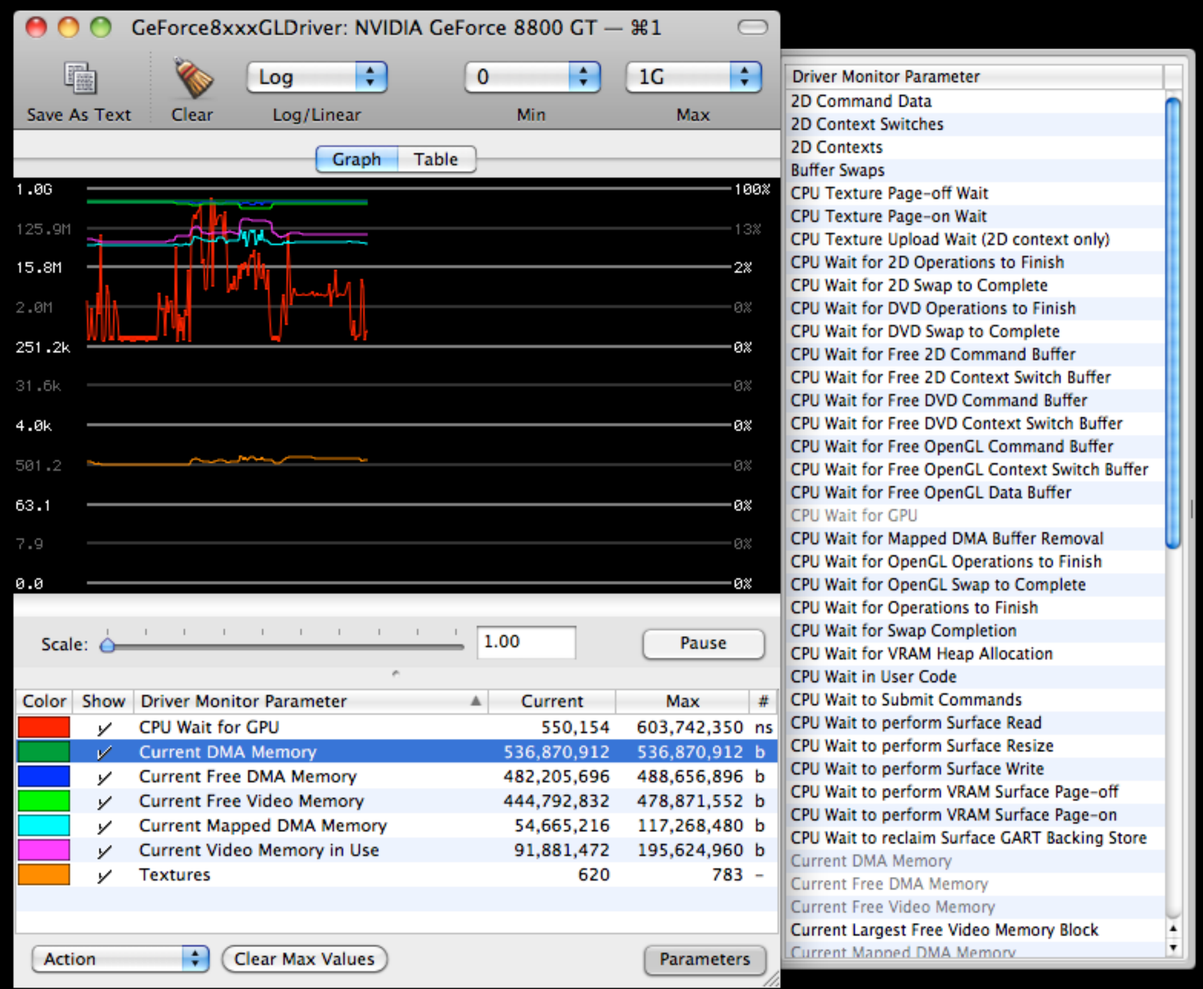
- Set breakpoints
  - GL entrypoints
  - GL errors
  - Thread conflicts
  - Renderer changes
  - Software fallback
- Trace GL calls
- View GL state
- View GL objects
- View the draw buffer



OpenGL Driver Monitor

Driver counters and statistics

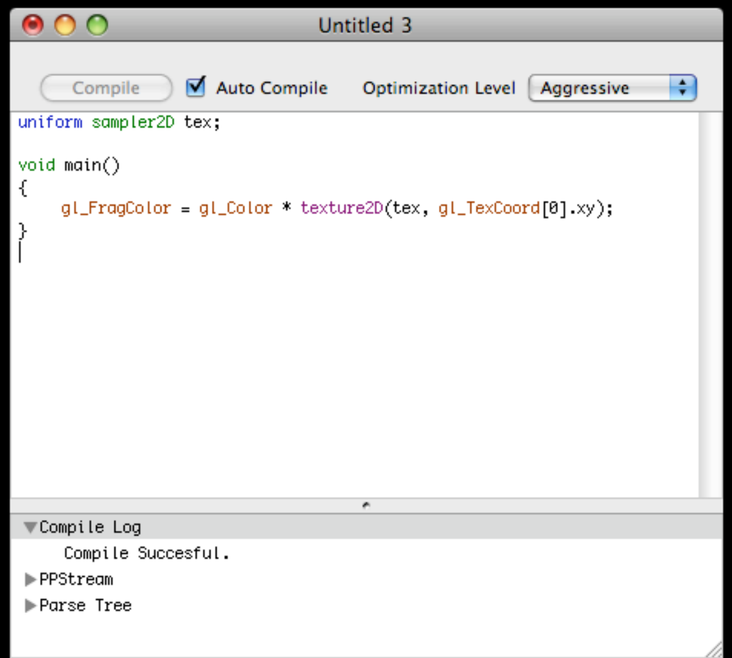
- Monitor CPU stalls
- Find leaks and paging
- Interesting driver statistics
  - CPU wait for GPU
  - Current free video memory
  - Surface page off data
  - Texture page off data

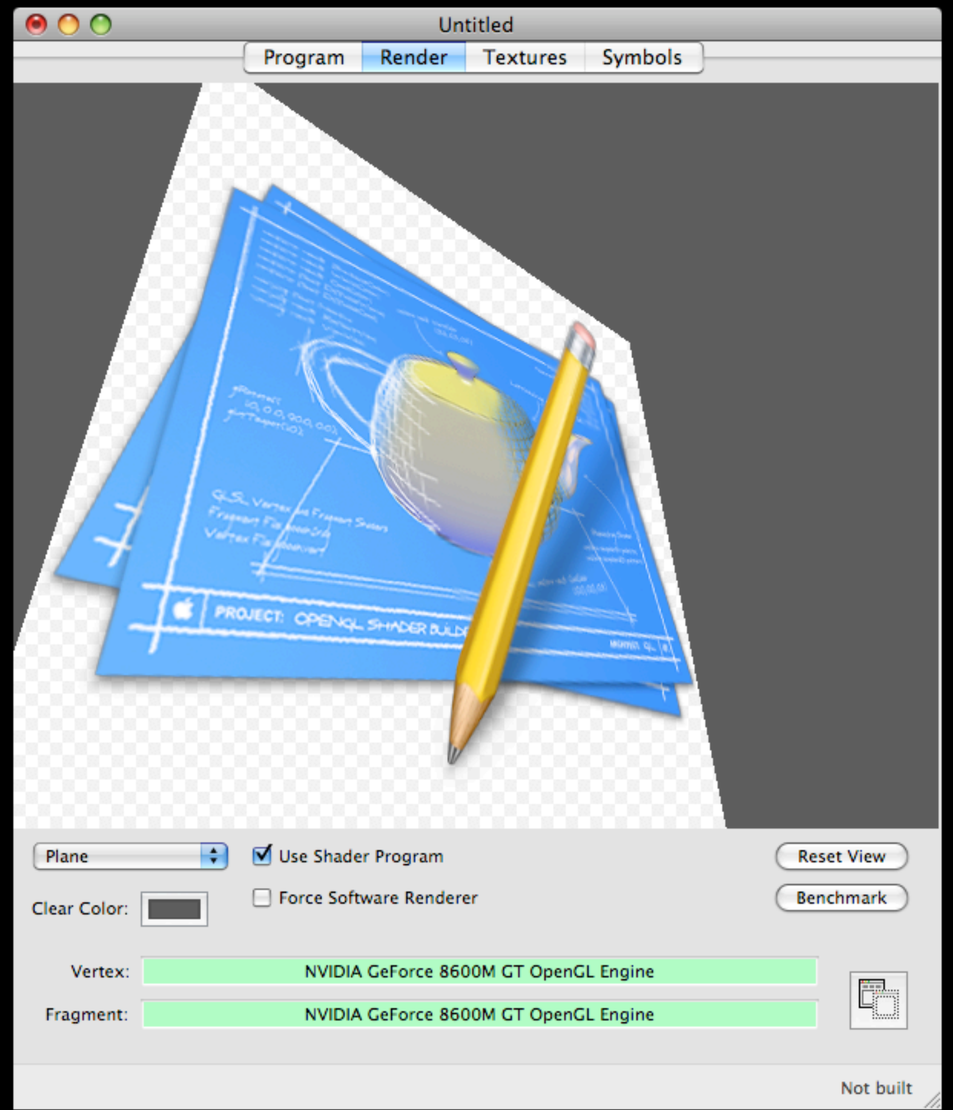


OpenGL Shader Builder

Vertex, geometry and fragment program editor

- GLSL and ARB assembly languages
- Benchmark shader performance

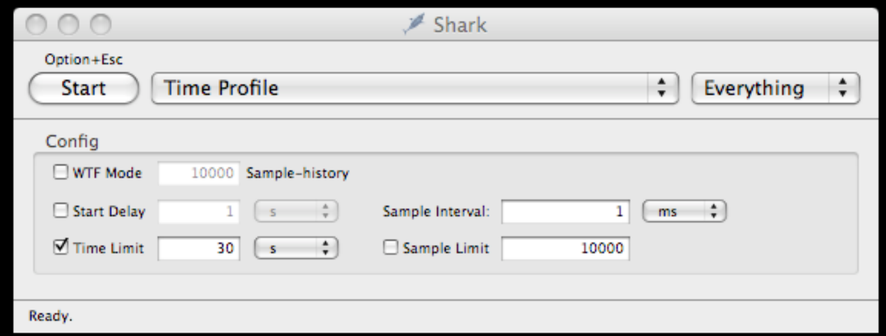




Shark

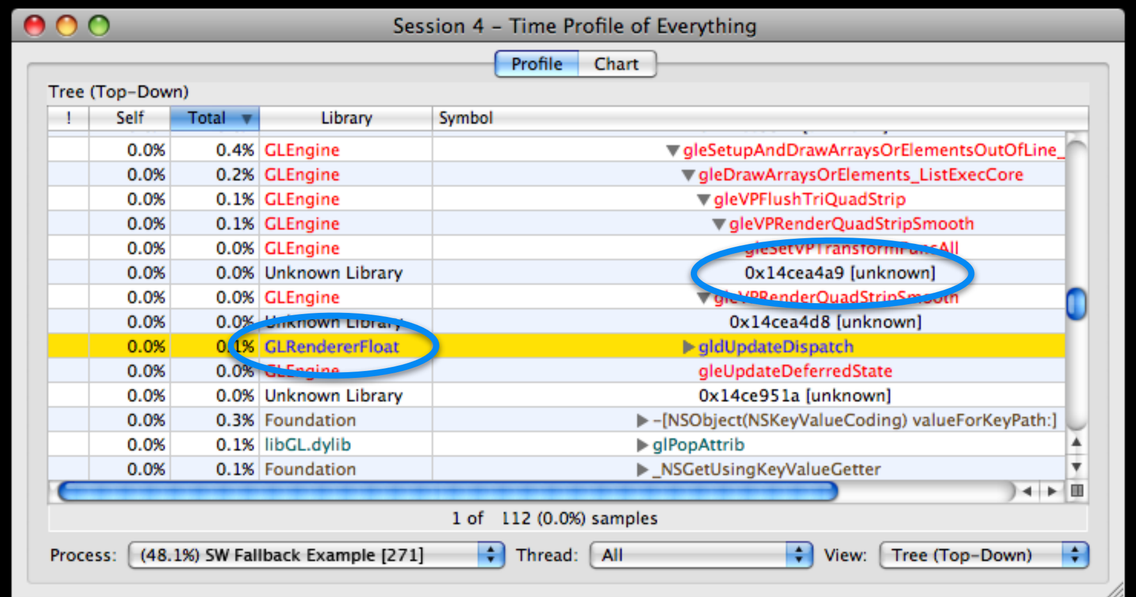
Code profiler

- Look out for these symbols!
  - Software Renderer: GLRendererFloat
  - RTC symbols: 0x4DD4355 [unknown]
  - MT Sync: gleFinishCommandBuffer



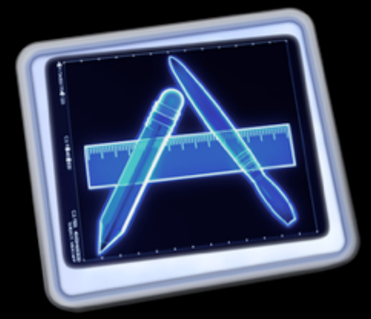
- Drivers symbols are ambiguous
  - gldGetTextureLevel+0x1234

- New to Shark? Go see the sessions!



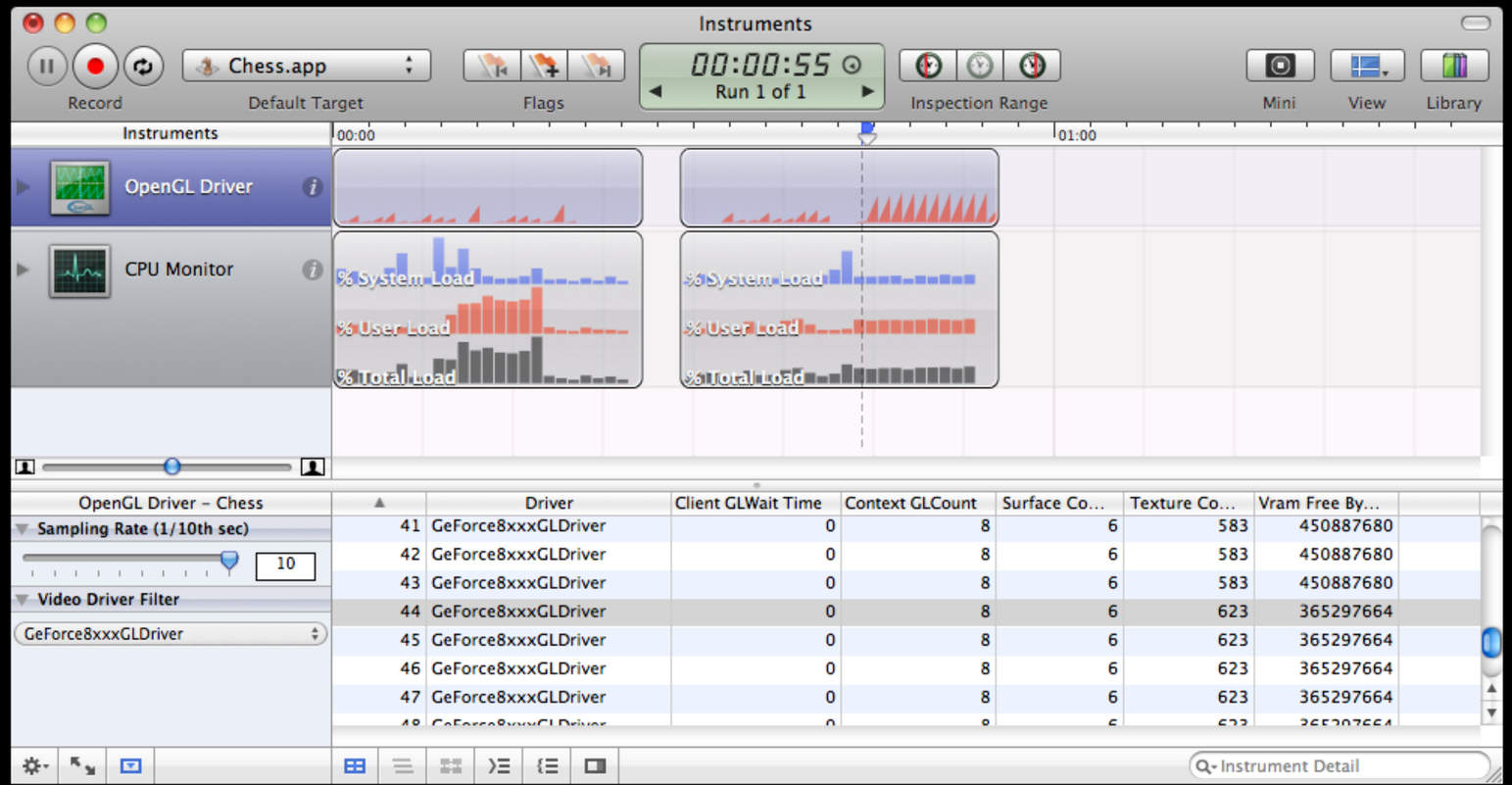
Instruments

Visualize application performance

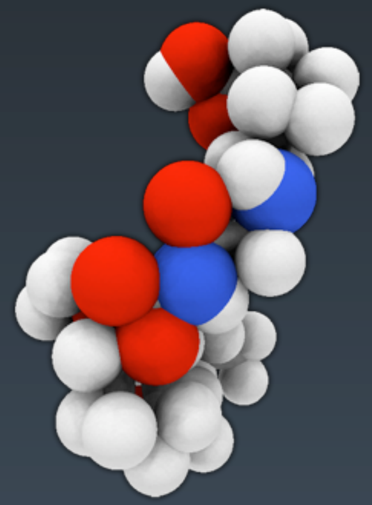


- With integrated OpenGL driver monitor statistics

  Remember! GPU statistics are per GPU, not per application



Molecules Demo



Chris Niederauer
Once beat Chuck Norris in Quake

More Information

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Documentation

Mac OS X OpenGL Developer Site
http://developer.apple.com/opengl/

Related Sessions

OpenGL ES Overview for iPhone OS	OpenGL ES	Presidio Wednesday 2:00PM
Advanced Rendering and Shading	OpenGL OpenGL ES	Presidio Wednesday 3:30PM
OpenGL ES Tuning and Techniques	OpenGL OpenGL ES	Presidio Wednesday 5:00PM
Introduction to OpenCL	OpenCL	Marina Thursday 9:00AM
Harnessing the Power of OpenCL	OpenCL	Marina Thursday 10:30AM
Mastering OpenCL	OpenCL	Marina Thursday 2:00PM
Performance Tuning with Shark on Mac and iPhone		North Beach Friday 9:00AM

Labs

OpenGL for the Mac Lab	Graphics and Media Lab A Thursday 12:00PM
OpenGL ES Lab	Graphics and Media Lab B Thursday 12:00PM
OpenCL Lab	Graphics and Media Lab B Thursday 3:30PM

Q&A

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